

We Claim:

1. A semiconductor structure comprising:
a monocrystalline silicon substrate;
5 an accommodating buffer layer overlying said monocrystalline silicon substrate;
and
a monocrystalline oxygen-doped material layer overlying said accommodating
buffer layer.
- 10 2. The semiconductor structure of claim 1, further comprising:
a monocrystalline material layer overlying said monocrystalline oxygen-doped
material layer.
3. The semiconductor structure of claim 2, wherein said monocrystalline material
15 layer comprises a compound semiconductor.
4. The semiconductor structure of claim 2, wherein said monocrystalline material
layer comprises a material selected from one of: Group III-V compound
semiconductors, mixed III-V compounds, Group II-VI compound semiconductors,
20 mixed II-VI compounds, Group IV-VI compound semiconductors, and mixed IV-VI
compounds.
5. The semiconductor structure of claim 2, wherein said monocrystalline material
layer comprises a material selected from one of: gallium arsenide, gallium indium
25 arsenide, gallium aluminum arsenide, indium phosphide, cadmium sulfide, cadmium
mercury telluride, zinc selenide, zinc sulfur selenide, lead selenide, lead telluride, and
lead sulfide selenide.

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6. The semiconductor structure of claim 1, wherein said accommodating buffer layer comprises a material selected from at least one of: alkaline earth metal titanates, alkaline earth metal zirconates, alkaline earth metal hafnates, alkaline earth metal tantalates, alkaline earth metal ruthenates, alkaline earth metal niobates, alkaline earth metal vanadates, perovskite oxides such as alkaline earth metal tin-based perovskites, lanthanum aluminate, lanthanum scandium oxide, and gadolinium oxide.
7. The semiconductor structure of claim 1, wherein said monocrystalline oxygen-doped material layer comprises an oxygen-doped compound semiconductor.
8. The semiconductor structure of claim 1, wherein said monocrystalline oxygen-doped material layer comprises a material selected from one of: Group III-V compound semiconductors, mixed III-V compounds, Group II-VI compound semiconductors, mixed II-VI compounds, Group IV-VI compound semiconductors, and mixed IV-VI compounds.
9. The semiconductor structure of claim 1, wherein said monocrystalline oxygen-doped material layer comprises a material selected from one of: gallium arsenide, gallium indium arsenide, gallium aluminum arsenide, indium phosphide, cadmium sulfide, cadmium mercury telluride, zinc selenide, zinc sulfur selenide, lead selenide, lead telluride, and lead sulfide selenide.
10. The semiconductor structure of claim 1, wherein said accommodating buffer layer has a thickness in the range of from about 2 to about 100 nanometers.
11. The semiconductor structure of claim 1, wherein the monocrystalline oxygen-doped material layer has a thickness in the range of from about 5 to about 500 nanometers.

12. The semiconductor structure of claim 1, wherein the monocrystalline oxygen-doped material layer has a thickness in the range of from about 100 to about 250 nanometers.

5 13. The semiconductor structure of claim 1, further comprising an amorphous oxide interface layer formed between said substrate and said accommodating buffer layer.

10 14. The semiconductor structure of claim 1, further comprising a template layer formed overlying said accommodating buffer layer and underlying said monocrystalline oxygen-doped material layer.

15 15. The semiconductor structure of claim 14, wherein said template layer comprises a Zintl-type phase material.

16 16. The semiconductor structure of claim 15, wherein said Zintl-type phase material comprises at least one of SrAl_2 , $(\text{MgCaYb})\text{Ga}_2$, $(\text{Ca,Sr,Eu,Yb})\text{In}_2$, BaGe_2As , and SrSn_2As_2 .

20 17. The semiconductor structure of claim 14, wherein said template layer comprises a surfactant material.

18. The semiconductor structure of claim 17, wherein said surfactant material comprises at least one of Al, Bi, In, and Ga.

25 19. The semiconductor structure of claim 17, wherein said template layer further comprises a capping layer.

20. The semiconductor structure of claim 19, wherein said capping layer is formed by exposing said surfactant material to a cap-inducing material.

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21. The semiconductor structure of claim 20, wherein said cap-inducing material comprises at least one of As, P, Sb, and N.

22. The semiconductor structure of claim 14, wherein said template layer comprises
5 a capping layer formed of about 1-10 monolayers of one of a material M-N and a material M-O-N, wherein M is selected from at least one of Zr, Hf, Sr, and Ba and N is selected from at least one of As, P, Ga, Al, and In.

23. The semiconductor structure of claim 1, wherein said accommodating buffer
10 layer is formed of a monocrystalline oxide material and is subsequently heat treated to convert said monocrystalline oxide material to an amorphous oxide.

24. The semiconductor structure of claim 1, further comprising an additional
15 monocrystalline oxygen-doped buffer layer epitaxially grown overlying said accommodating buffer layer and underlying said monocrystalline oxygen-doped material layer.

25. The semiconductor structure of claim 24, wherein said additional
20 monocrystalline oxygen-doped buffer layer comprises at least one of a semiconductor material, a compound semiconductor material, a metal and a non-metal.

26. The semiconductor structure of claim 24, wherein said additional
monocrystalline oxygen-doped buffer layer comprises a material selected from one of:
25 gallium arsenide, gallium indium arsenide, gallium aluminum arsenide, indium phosphide, cadmium sulfide, cadmium mercury telluride, zinc selenide, zinc sulfur selenide, lead selenide, lead telluride, and lead sulfide selenide.

27. The semiconductor structure of claim 1, wherein said monocrystalline silicon
30 substrate is approximately 300 mm in diameter.

28. The semiconductor structure of claim 1, said monocrystalline oxygen-doped material layer having an approximately constant oxygen concentration throughout said monocrystalline oxygen-doped material layer.

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- 5 29. The semiconductor structure of claim 1, said monocrystalline oxygen-doped mater layer having a decreasing concentration of oxygen from a first surface of said monocrystalline oxygen-doped material layer to a second surface of said monocrystalline oxygen-doped material layer.

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30. A process for fabricating a semiconductor structure comprising:
providing a monocrystalline silicon substrate;
epitaxially depositing a monocrystalline accommodating buffer layer overlying
said monocrystalline silicon substrate; and
5 epitaxially depositing a monocrystalline oxygen-doped material layer overlying
said monocrystalline accommodating buffer layer.

31. The process of claim 30, further comprising:
epitaxially depositing a monocrystalline material layer overlying said
10 monocrystalline oxygen-doped material layer.

32. The process of claim 31, wherein said monocrystalline material layer comprises
a compound semiconductor.

15 33. The process of claim 31, wherein said monocrystalline material layer comprises
a material selected from one of: Group III-V compound semiconductors, mixed III-V
compounds, Group II-VI compound semiconductors, mixed II-VI compounds, Group
IV-VI compound semiconductors, and mixed IV-VI compounds.

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20 34. The process of claim 31, wherein said monocrystalline material layer comprises
a material selected from one of: gallium arsenide, gallium indium arsenide, gallium
aluminum arsenide, indium phosphide, cadmium sulfide, cadmium mercury telluride,
zinc selenide, zinc sulfur selenide, lead selenide, lead telluride, and lead sulfide
selenide.

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35. The process of claim 30, wherein said accommodating buffer layer comprises a material selected from at least one of: alkaline earth metal titanates, alkaline earth metal zirconates, alkaline earth metal hafnates, alkaline earth metal tantalates, alkaline earth metal ruthenates, alkaline earth metal niobates, alkaline earth metal vanadates, perovskite oxides such as alkaline earth metal tin-based perovskites, lanthanum aluminate, lanthanum scandium oxide, and gadolinium oxide.

36. The process of claim 30, wherein said monocrystalline oxygen-doped material layer comprises an oxygen-doped compound semiconductor.

37. The process of claim 30, wherein said monocrystalline oxygen-doped material layer comprises a material selected from one of: Group III-V compound semiconductors, mixed III-V compounds, Group II-VI compound semiconductors, mixed II-VI compounds, Group IV-VI compound semiconductors, and mixed IV-VI compounds.

38. The process of claim 30, wherein said monocrystalline oxygen-doped material layer comprises a material selected from one of: gallium arsenide, gallium indium arsenide, gallium aluminum arsenide, indium phosphide, cadmium sulfide, cadmium mercury telluride, zinc selenide, zinc sulfur selenide, lead selenide, lead telluride, and lead sulfide selenide.

39. The process of claim 30, wherein said epitaxially depositing a monocrystalline accommodating buffer layer comprises epitaxially depositing said monocrystalline accommodating buffer layer to a thickness in the range of from about 2 to about 100 nanometers.

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47. The process of claim 46, wherein said surfactant material comprises at least one of Al, Bi, In, and Ga.

48. The process of claim 46, wherein said template layer further comprises a capping layer.

49. The process of claim 48, wherein said capping layer is formed by exposing the
5 surfactant material to a cap-inducing material.

50. The process of claim 49, wherein said cap-inducing material comprises at least one of As, P, Sb, and N.

10 51. The process of claim 43, wherein said forming a template layer comprises capping said monocrystalline accommodating buffer layer with about 1-10 monolayers of one of a material M-N and a material M-O-N, wherein M is selected from at least one of Zr, Hf, Sr, and Ba and N is selected from at least one of As, P, Ga, Al, and In.

15 52. The process of claim 30, further comprising epitaxially depositing an additional monocrystalline oxygen-doped buffer layer overlying said accommodating buffer layer and underlying said monocrystalline oxygen-doped material layer.

20 53. The process of claim 52, wherein said additional monocrystalline oxygen-doped buffer layer comprises at least one of a semiconductor material, a compound semiconductor material, a metal and a non-metal.

25 54. The process of claim 52, wherein said additional monocrystalline oxygen-doped buffer layer comprises a material selected from one of: gallium arsenide, gallium indium arsenide, gallium aluminum arsenide, indium phosphide, cadmium sulfide, cadmium mercury telluride, zinc selenide, zinc sulfur selenide, lead selenide, lead telluride, and lead sulfide selenide.

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55. The process of claim 30, wherein said monocrystalline accommodating buffer layer is formed of a monocrystalline oxide material and said process further comprises heat treating said monocrystalline oxide material to convert said monocrystalline oxide material to an amorphous oxide material.

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56. The process of claim 30, wherein each of the steps of epitaxially depositing comprises epitaxially depositing by a process selected from the group consisting of MBE, MOCVD, MEE, CVD, PVD, PLD, CSD and ALE.

10 57. The process of claim 30, wherein said monocrystalline silicon substrate is approximately 300 mm in diameter.

58. The process of claim 30, wherein said monocrystalline oxygen-doped material layer has an approximately constant oxygen concentration throughout said

15 monocrystalline oxygen-doped material layer.

59. The process of claim 30, wherein said monocrystalline oxygen-doped material layer has a decreasing concentration of oxygen from a first surface of said monocrystalline oxygen-doped material layer to a second surface of said

20 monocrystalline oxygen-doped material layer.

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60. A process for fabricating a semiconductor structure comprising:
providing a monocrystalline silicon substrate having a first lattice constant;
selecting a first material that when properly oriented has a second lattice
constant and crystalline structure such that said first material can be deposited as a
monocrystalline film overlying said monocrystalline silicon substrate, said second
lattice constant being different than said first lattice constant;
depositing a first monocrystalline film of said first material, said first
monocrystalline film overlying said monocrystalline silicon substrate;
forming an amorphous interface layer at an interface between said first
monocrystalline film and said monocrystalline silicon substrate, said amorphous
interface layer having a thickness sufficient to relieve strain in said first monocrystalline
film;
selecting a first compound semiconductor material that when properly oriented
has a third lattice constant and crystalline structure such that said first compound
semiconductor material can be deposited as a monocrystalline compound
semiconductor film on said first monocrystalline film, said second lattice constant being
substantially matched to said third lattice constant; and
depositing in a first partial pressure of oxygen a first monocrystalline oxygen-
doped film of said first compound semiconductor material overlying said first
monocrystalline film.

61. The process of claim 60, further comprising depositing a second monocrystalline
film of said first compound semiconductor material, said second monocrystalline film
overlying said first monocrystalline oxygen-doped film.

62. The process of claim 60, wherein said first compound semiconductor material
comprises a material selected from one of: Group III-V compound semiconductors,
mixed III-V compounds, Group II-VI compound semiconductors, mixed II-VI
compounds, Group IV-VI compound semiconductors, and mixed IV-VI compounds.

63. The process of claim 60, wherein said first compound semiconductor material comprises a material selected from one of: gallium arsenide, gallium indium arsenide, gallium aluminum arsenide, indium phosphide, cadmium sulfide, cadmium mercury telluride, zinc selenide, zinc sulfur selenide, lead selenide, lead telluride, and lead sulfide selenide.

64. The process of claim 60, wherein said first material comprises a material selected from at least one of: alkaline earth metal titanates, alkaline earth metal zirconates, alkaline earth metal hafnates, alkaline earth metal tantalates, alkaline earth metal ruthenates, alkaline earth metal niobates, alkaline earth metal vanadates, perovskite oxides such as alkaline earth metal tin-based perovskites, lanthanum aluminate, lanthanum scandium oxide, and gadolinium oxide.

65. The process of claim 60, wherein said depositing a first monocrystalline film comprises depositing said first monocrystalline film to a thickness in the range of from about 2 to about 100 nanometers.

66. The process of claim 60, wherein said depositing a first monocrystalline oxygen-doped film comprises depositing said first monocrystalline oxygen-doped film to a thickness in the range of from about 5 to about 500 nanometers.

67. The process of claim 60, wherein said depositing a first monocrystalline oxygen-doped film comprises depositing said first monocrystalline oxygen-doped film to a thickness in the range of from about 100 to about 250 nanometers.

68. The process of claim 60, further comprising forming a template layer overlying said first monocrystalline film and underlying said first monocrystalline oxygen-doped film.

69. The process of claim 68, wherein said template layer comprises a Zintl-type phase material.

70. The process of claim 69, wherein said Zintl-type phase material comprises at least one of SrAl_2 , $(\text{MgCaYb})\text{Ga}_2$, $(\text{Ca,Sr,Eu,Yb})\text{In}_2$, BaGe_2As , and SrSn_2As_2 .

71. The process of claim 68, wherein said template layer comprises a surfactant material.

72. The process of claim 71, wherein said surfactant material comprises at least one of Al, Bi, In, and Ga.

73. The process of claim 71, wherein said template layer further comprises a capping layer.

74. The process of claim 73, wherein said capping layer is formed by exposing the surfactant material to a cap-inducing material.

75. The process of claim 74, wherein said cap-inducing material comprises at least one of As, P, Sb, and N.

76. The process of claim 68, wherein said forming a template layer comprises capping said monocrystalline accommodating buffer layer with about 1-10 monolayers of one of a material M-N and a material M-O-N, wherein M is selected from at least one of Zr, Hf, Sr, and Ba and N is selected from at least one of As, P, Ga, Al, and In.

77. The process of claim 60, further comprising:

selecting a second compound semiconductor material that when properly oriented has a fourth lattice constant and crystalline structure such that said second compound semiconductor material can be deposited as a monocrystalline compound semiconductor film overlying said first monocrystalline film; and

depositing in a second partial pressure of oxygen a second monocrystalline oxygen-doped film of said second compound semiconductor material overlying said first monocrystalline film and underlying said first monocrystalline oxygen-doped film, said fourth lattice constant being substantially matched to said third lattice constant.

78. The process of claim 77, wherein said second compound semiconductor material comprises at least one of a semiconductor material, a compound semiconductor material, a metal and a non-metal.

79. The process of claim 77, wherein said second compound semiconductor material comprises a material selected from one of: gallium arsenide, gallium indium arsenide, gallium aluminum arsenide, indium phosphide, cadmium sulfide, cadmium mercury telluride, zinc selenide, zinc sulfur selenide, lead selenide, lead telluride, and lead sulfide selenide.

80. The process of claim 60, wherein said first monocrystalline film is formed of monocrystalline oxide material and said process further comprises heat treating said monocrystalline oxide material to convert said monocrystalline oxide material to an amorphous oxide material.

81. The process of claim 60, wherein each of the steps of depositing comprises depositing by a process selected from the group consisting of MBE, MOCVD, MEE, CVD, PVD, PLD, CSD and ALE.

82. The process of claim 60, wherein said monocrystalline silicon substrate is approximately 300 mm in diameter.

5 83. The process of claim 60, further comprising establishing said first partial pressure of oxygen before said depositing said first monocrystalline oxygen-doped film.

84. The process of claim 60, further comprising decreasing said first partial pressure of oxygen during said depositing said first monocrystalline oxygen-doped film.

10 85. The process of claim 60, further comprising maintaining said first partial pressure of oxygen at an approximately constant partial pressure during said depositing said first monocrystalline oxygen-doped film.

15 86. The process of claim 60 further comprising increasing said first partial pressure of oxygen during said depositing said first monocrystalline oxygen-doped film.

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87. A semiconductor device structure comprising:

a monocrystalline silicon substrate;

a monocrystalline accommodating buffer layer overlying said monocrystalline silicon substrate;

5 a monocrystalline oxygen-doped material layer overlying said monocrystalline accommodating buffer layer;

a monocrystalline material layer overlying said monocrystalline oxygen-doped material layer;

10 a first semiconductor component, at least a portion of which is formed in said monocrystalline silicon substrate; and

a second semiconductor component, at least a portion of which is formed in said monocrystalline material layer, said second semiconductor component being electrically coupled to said first semiconductor component.

15 88. The semiconductor device structure of claim 87, wherein said monocrystalline material layer comprises a compound semiconductor.

89. The semiconductor device structure of claim 87, wherein said monocrystalline material layer comprises a material selected from one of: Group III-V compound
20 semiconductors, mixed III-V compounds, Group II-VI compound semiconductors, mixed II-VI compounds, Group IV-VI compound semiconductors, and mixed IV-VI compounds.

90. The semiconductor device structure of claim 87, wherein said monocrystalline
25 material layer comprises a material selected from one of: gallium arsenide, gallium indium arsenide, gallium aluminum arsenide, indium phosphide, cadmium sulfide, cadmium mercury telluride, zinc selenide, zinc sulfur selenide, lead selenide, lead telluride, and lead sulfide selenide.

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91. The semiconductor device structure of claim 87, wherein said monocrystalline accommodating buffer layer comprises a material selected from at least one of: alkaline earth metal titanates, alkaline earth metal zirconates, alkaline earth metal hafnates, alkaline earth metal tantalates, alkaline earth metal ruthenates, alkaline earth metal niobates, alkaline earth metal vanadates, perovskite oxides such as alkaline earth metal tin-based perovskites, lanthanum aluminate, lanthanum scandium oxide, and gadolinium oxide.
92. The semiconductor device structure of claim 87, wherein said monocrystalline oxygen-doped material layer comprises an oxygen-doped compound semiconductor.
93. The semiconductor device structure of claim 87, wherein said monocrystalline oxygen-doped material layer comprises a material selected from one of: Group III-V compound semiconductors, mixed III-V compounds, Group II-VI compound semiconductors, mixed II-VI compounds, Group IV-VI compound semiconductors, and mixed IV-VI compounds.
94. The semiconductor device structure of claim 87, wherein said monocrystalline oxygen-doped material layer comprises a material selected from one of: gallium arsenide, gallium indium arsenide, gallium aluminum arsenide, indium phosphide, cadmium sulfide, cadmium mercury telluride, zinc selenide, zinc sulfur selenide, lead selenide, lead telluride, and lead sulfide selenide.
95. The semiconductor device structure of claim 87, wherein said accommodating buffer layer has a thickness in the range of from about 2 to about 100 nanometers.
96. The semiconductor device structure of claim 87, wherein said monocrystalline oxygen-doped material layer has a thickness in the range of from about 5 to about 500 nanometers.

97. The semiconductor device structure of claim 87, wherein said monocrystalline oxygen-doped material layer has a thickness in the range of from about 100 to about 250 nanometers.

5 98. The semiconductor device structure of claim 87, further comprising an amorphous oxide interface layer formed between said substrate and said accommodating buffer layer.

99. The semiconductor device structure of claim 87, further comprising a template
10 layer formed overlying said accommodating buffer layer and underlying said monocrystalline oxygen-doped material layer.

100. The semiconductor device structure of claim 99, wherein said template layer
15 comprises a Zintl-type phase material.

101. The semiconductor device structure of claim 100, wherein said Zintl-type phase material comprises at least one of SrAl_2 , $(\text{MgCaYb})\text{Ga}_2$, $(\text{Ca,Sr,Eu,Yb})\text{In}_2$, BaGe_2As , and SrSn_2As_2 .

20 102. The semiconductor device structure of claim 99, wherein said template layer comprises a surfactant material.

103. The semiconductor device structure of claim 102, wherein said surfactant material comprises at least one of Al, Bi, In, and Ga.
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104. The semiconductor device structure of claim 102, wherein said template layer further comprises a capping layer.

105. The semiconductor device structure of claim 104, wherein said capping layer is
30 formed by exposing said surfactant material to a cap-inducing material.

106. The semiconductor device structure of claim 105, wherein said cap-inducing material comprises at least one of As, P, Sb, and N.

107. The semiconductor device structure of claim 99, wherein said template layer
5 comprises a capping layer formed of about 1-10 monolayers of one of a material M-N and a material M-O-N, wherein M is selected from at least one of Zr, Hf, Sr, and Ba and N is selected from at least one of As, P, Ga, Al, and In.

108. The semiconductor device structure of claim 87, wherein said accommodating
10 buffer layer is formed of a monocrystalline oxide material and is subsequently heat treated to convert said monocrystalline oxide material to an amorphous oxide material.

109. The semiconductor device structure of claim 87, further comprising an
15 additional oxygen-doped buffer layer epitaxially grown overlying said accommodating buffer layer and underlying said monocrystalline oxygen-doped material layer.

110. The semiconductor device structure of claim 109, wherein said additional
20 oxygen-doped buffer layer comprises at least one of a semiconductor material, a compound semiconductor material, a metal and a non-metal.

111. The semiconductor device structure of claim 109, wherein said additional
oxygen-doped buffer layer comprises a material selected from one of: gallium arsenide,
gallium indium arsenide, gallium aluminum arsenide, indium phosphide, cadmium
sulfide, cadmium mercury telluride, zinc selenide, zinc sulfur selenide, lead selenide,
25 lead telluride, and lead sulfide selenide.

112. The semiconductor device structure of claim 87, wherein said monocrystalline silicon substrate is approximately 300 mm in diameter.

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113. The semiconductor device structure of claim 87, said monocrystalline oxygen-dope material layer having an approximately constant oxygen concentration throughout said monocrystalline oxygen-doped material layer.

- 5 114. The semiconductor device structure of claim 87, said monocrystalline oxygen-doped material layer having a graded oxygen concentration.

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